Tropical Convection and Microphysics Equilibrium

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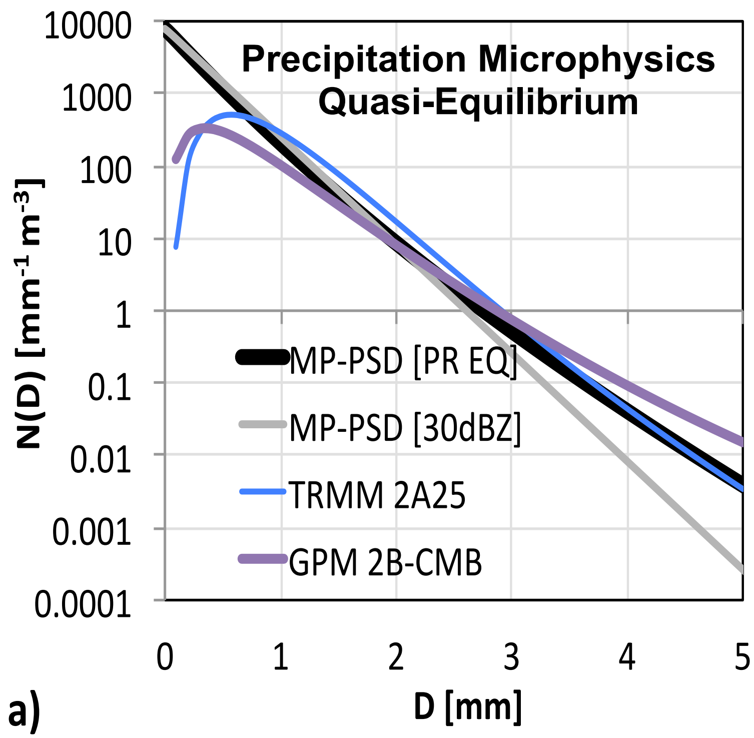

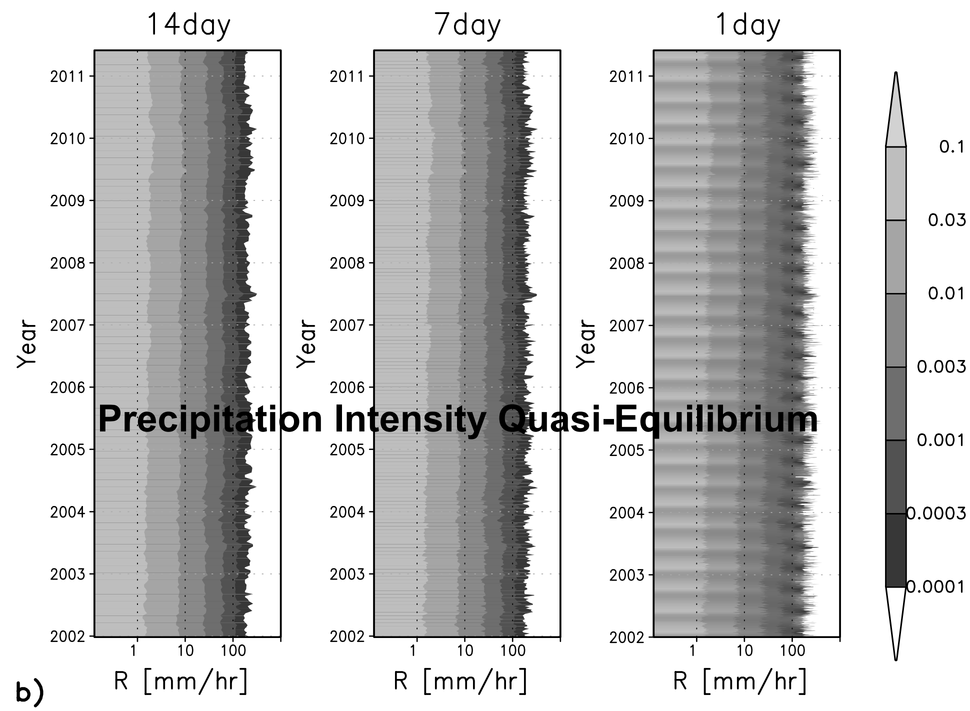

When TRMM observation are integrated over the entire tropics, precipitation particle size distributions (microphysics) and precipitation intensity (convection) spectrum become equilibrium states on the month-to-daily time scale, regardless of variability of tropical meteorology.

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References:

Matsui, T., W.-K. Tao, S. J. Munchak, G. Huffman, and M. Grecu (2015), Satellite View of Quasi-Equilibrium States in Tropical Convection and Precipitation Microphysics, *Geophysical Research Letters*, 42, doi:10.1002/2015GL063261

Data Sources: The data used in this study is TRMM Precipitation Radar (PR) attenuation-corrected echo profile from 2A25 and TRMM Microwave Imager (TMI) 89GHz brightness temperature (Tb_{85}) from 1B11. Precipitation intensity frequency fare derived rom merged precipitation data from (3B42). GPM precipitation microphysics is derived from GPM radar-radiometer combined retrievals (GPM 2A-CMB). All data are distributed by NASA Precipitation Processing System (PPS).

Technical Description of Figures:

Microphysics Quasi-Equilibrium: Tropics-integrated precipitation particle size distributions (PSD) are estimated from the TRMM PR with Marshal-Palmer relationship, the TRMM PR algorithm (2A25), and the GPM combined algorithm (GPM 2A-CMB). These distribution shapes are invariant over time (i.e., equilibrium state). The equilibrium PSD of GPM 2B-COMB is more broadly distributed than that from PR 2A25 due to different orbital patterns between TRMM and GPM satellites and also differences in the algorithm sophistications.

Precipitation Intensity Quasi-Equilibrium. TRMM 3B42 datasets provide 3-hourly 0.25°-grid precipitation estimates. With this, time series of the precipitation intensity frequencies are created by averaging for different time intervals (14 days, 7 days, and 1 day) over entire tropics to investigate equilibrium adjustment time. Comparing three averaging intervals, the time series of 1-day averaging is slightly noisier than 7-day, which is noisier than the14-day composite; however structures appears to be very similar between each other. This suggest that planetary-scale precipitation intensity (i.e., moist convection) spectrum could be equilibrium down to at least a one-day time period.

Scientific significance, societal relevance, and relationships to future missions: Microphysics and moist convection remained as unresolved physical process up to now. However, such complex phenomena can be explained by simple relationship when the TRMM observation are integrated over the entire tropics on the month-to-day scale. Namely, spectrum shape of precipitation intensity and microphysics has virtually no change over time with extremely large samples over the entire tropics.

The Missing Tropical Arm of Atlantic Multidecadal Oscillation

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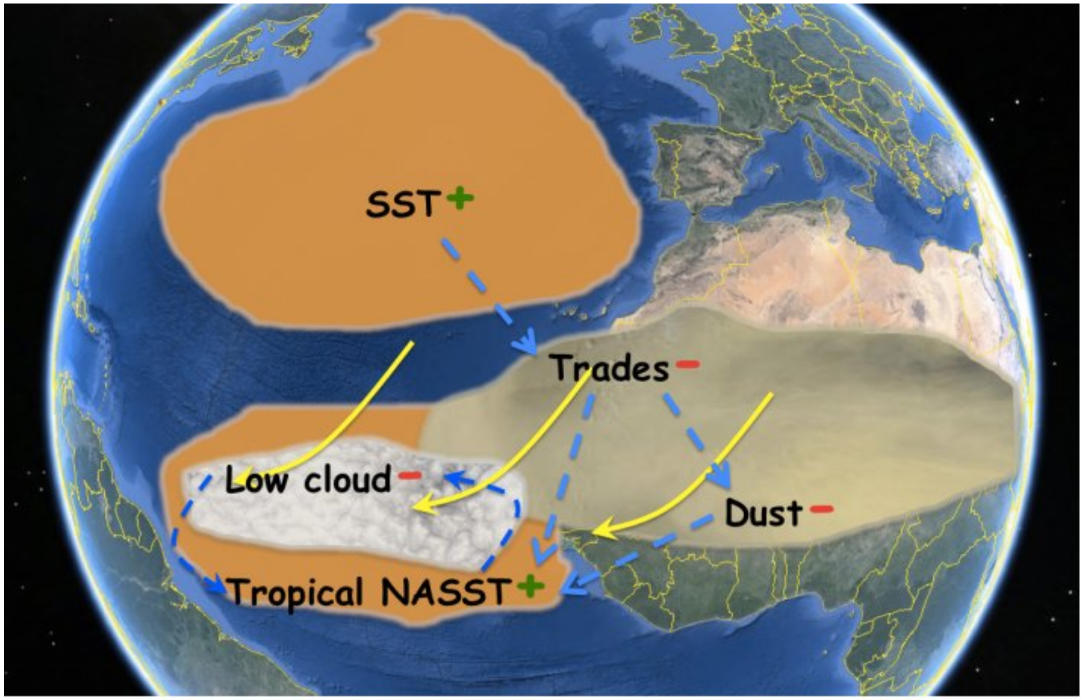

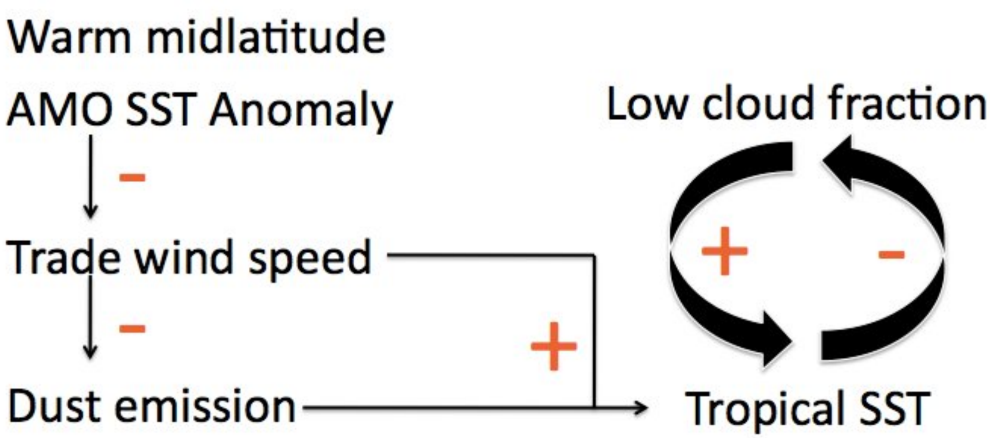

In the current generation of global climate models, the tropical arm of the Atlantic Multidecadal Oscillation is often absent. Using many years of satellite observations, we show that positive feedbacks from low clouds and dust are critical. However, models fail to produce these feedbacks because of missing both physics and a key coupled atmosphere-ocean teleconnection between high and low latitudes.

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References:

Yuan, T., L. Oreopoulos, M. Zelinka, H. Yu, J. R. Norris, M. Chin, S. Platnick, and K. Meyer (2016), Positive low cloud and dust feedbacks amplify tropical North Atlantic Multidecadal Oscillation, Geophys. Res. Lett., 43, 1349–1356, doi:10.1002/2016GL067679.

Data Sources: MODIS and ISCCP cloud products, MERRA reanalysis, GOCART model results, CMIP5 cloud fields. We acknowledge funding support from the NASA MAP program.

Technical Description of Figures:

Graphic 1: The North Atlantic sea surface temperature (SST) undergoes coherent multidecadal oscillations with a period of about 60–80 years, known as the Atlantic Multidecadal Oscillation (AMO) (also referred to as the Atlantic Multidecadal Variability) The warm SST anomalies in the mid- to high- latitude North Atlantic can generate atmospheric responses that weaken trade wind speed in the tropical North Atlantic. Weaker trade winds create warm SST anomalies over the tropical North Atlantic, which are amplified by positive low cloud feedback. Reduced wind speed also decrease dust emission over the Saharan source regions and dust loading over the tropical ocean, which amplifies the SST positive anomaly over the tropical arm of the AMO. Both low cloud and dust positive feedbacks play a critical role in the appearance and maintenance of the tropical arm of the AMO.

Scientific significance, societal relevance, and relationships to future missions: It is the first study that highlights the connection between mid- to low latitude SST anomalies in the North Atlantic and discovers the positive feedbacks from dust and low clouds. Our analysis reveals the common weakness in current global climate models that fail to simulate the tropical arm of AMO that is an important source of predictability at decadal time scale, an important new research area. The study also underscores that for low frequency climatic oscillations like the AMO long time series of satellite data are essential for understanding the nature and behavior of the processes involved.